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Research Article

A detailed assessment of the land cover development in a territory with dispersed settlement area (case study Hriňová – Snohy, Slovakia)

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Abstract

This study focuses on the development of the landscape during a period of significant social changes in Central Europe from the middle of the 20th century, and evaluates the impact of the selected natural factors on landscape dynamics in the Snohy dispersed settlement area (cadaster of Hriňová, Slovakia). During the periods of feudalism and the democratic Czechoslovak Republic after 1918, private ownership of land prevailed on the territory of Slovakia. After 1948, in the period of the socialist establishment, the municipality was one of the few localities without collectivisation. We focused on the state and changes to the landscape structure based on remote sensing data analysis (1949, 2003, and 2018), as well as field research and archive photographs inspection. The study area is a part of the proposed Special Area of Conservation SKUEV4026 Meadows of Poľana and is situated near the border between the transition and buffer zones of the Poľana Biosphere Reserve. The state of land cover and its changes have been evaluated using a CORINE Land Cover modification at the 5th level. Results showed that the influence of the slope on agricultural extensification, deforestation, and afforestation, was the most pronounced. Since 1949, more than half of the land cover has changed across the study area. The most extensive changes were recorded in the spatial structure and composition of forest communities.

Key words: Dispersed area settlement, georelief, Hriňová, land cover, Poľana Biosphere Reserve, Slovakia, soil conditions

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Introduction

Land use and land cover

Stamp (1931) conducted some of the earliest studies dealing with the inspection of land use, utilizing legends built upon a combination of several functional and physiognomic features. Other crucial works were released by Anderson et al. (1976) and Heymann et al. (1994). When identifying and interpreting

different types of remote sensing images, physiognomic differences between the objects on the Earth's surface were emphasized by these authors. Similar objectives were aimed at by the CORINE Land Cover (CLC) programme, which established a technique for identifying land cover from satellite imagery with a resolution of 10–50 m, while including aspects of land use. With a scale of 1:100,000 and a minimum monitored area size of 25 ha, the CLC technique (Heymann et al. 1994; Büttner et al. 1998; Bossard et al. 2000) is appropriate for national or regional investigations.

The term land cover represents spatial objects on the Earth's surface, which are identified on the basis of morphostructural and physiognomic attributes (Feranec and Oťaheľ 2001). According to (Kopecká 2006), the term expresses the actual state of the landscape structure. By the term land cover change, Coppin et al. (2003) categorized change or gradual transition of one land cover class to another. Treitz and Rogan (2004), Rogan and Chen (2004), and Comber et al. (2005) all understand land cover as a physical formation of matter on the Earth's surface, which is represented by forests, grasslands, artificial surfaces, rocks, water, etc.

Oťaheľ and Feranec (1997, 2006) were among the first in Slovakia to focus on land cover changes identified from CORINE Land Cover data from 1970 to 2000. Analyses of landscape dynamics based on the spatial intensity of changes were published by Feranec et al. (2000), Feranec and Oťaheľ (2001), Boltižiar (2007), Oťaheľ and Feranec (1997) and Oťaheľ et al. (2011, 2017). Classifications of land cover changes were published by Čerňanský et al. (2003) and Kopecká (2006).

In recent decades, the topics of land use and land cover have been a relatively frequent part of historical, geographical, and landscape ecological research in Slovakia, as well as throughout the world. Some studies claim (Huba 1989; Petrovič 2006b; Hunziker et al. 2008; Bürgi et al. 2017), that landscape changes evaluation is largely linked to ongoing social processes. Land-use changes are increasingly being influenced by distant forces due to the globalization of many markets (Lambin and Meyfroidt 2011). Conversely, climate change can also influence land cover, resulting in a loss of forest cover from climate-related increases in disturbances (Flannigan et al. 2009), and the expansion of woody vegetation into grasslands (Kulmatiski and Beard 2013).

Dispersed settlement

In addition to Slovakia (Lauko 1985; Huba 2004; Petrovič 2006a; Petrovič and Petrikovičová 2021), dispersed settlement also occurs in many countries. As examples of studies of this type of settlement, we mention the following: Scandinavia (Norling 1960; Hansen 1972), Bulgaria (Hoffman 1964), Africa (Stone 1991; Donaldson and Boshoff 2001), Czechia (Löw and Míchal 2003; Vaishar and Šťastná 2019; Šťastná and Vaishar 2020), and the United States (Barnes and Robinson 1940). However, its occurrence in the aforementioned regions is spatially limited.

In Slovakia, dispersed settlement is a specific form of settlement, which is conditioned by specific historical and environmental factors. As a result of colonization waves in Slovakia, groups of irregularly-scattered settlements in different types of georelief were created. However, its genesis was rather diverse

(Huba 1989, 1990, 1997). The origin of dispersed settlements began in medieval times (Hoffmann 2014; Hanušin et al. 2020). Its basic function was soil cultivation in the marginal areas (Sitár 1967). The formation of dispersed settlements was linked to the three colonization waves: Wallachian (Chaloupecký 1947); Highlander and the "Kopaničiarska" (Petrovič and Petrikovičová 2021). Nowadays, in Slovakia, five different regions with scattered settlements and different land uses can be found (Verešík 1974).

Poľana Biosphere Reserve

One specific dispersed settlement was created in the Podpoľanie area. Within Poľana, as a part of the Western Carpathians Mountains, is one of the greatest European former volcanoes (original elevation at the time of its activity reached approximately 2500 m a.s.l.), and the highest volcanic mountain range in Slovakia. Elevation at the highest point is 1458 m a.s.l., while the lowest one reaches 460 m a.s.l. Poľana Biosphere Reserve (BR), established in 1990, is characterized by the common occurrence of both thermophilous and mountain plant species. Forests cover almost 85% of its area, with the moderate prevalence of coniferous forests (https://en.unesco.org/biosphere/eu-na/polana). To date, 1220 species of vascular plants have been described in the BR, out of which 80 species are in the categories of protection, threat, and rareness. With 174 species of birds, the Poľana BR has been recognized as an Important Birds Area of Slovakia. Besides biodiversity, land use dynamics is a crucial part of BRs research in Slovakia (Olah and Boltižiar 2009).

Historical evolution of Podpoľanie

The area of Podpoľanie is characterized by a specific type of homestead and colonization. In the initial phase of Wallachian colonization in the 13th–14th century, there were successive waves of settlement by inhabitants with a nomadic way of life, who were influenced by the political situation (Cojacaru 2014). Wallachian colonization was continuously followed by mining colonization (in some areas it overlapped it) from the 17th to 19th century (Petrovič and Petrikovičová 2021). Colonization affected not only sheep farming, but also culture, folklore, domestic production, and the very way of life in mountain and foothill areas. This area of Podpoľanie is characterized by high biodiversity and is connected mainly to the boundaries, which consist of the edges of field roads, original meadows, pastures, permanently grassy areas on former fields, or various waterlogged areas (Ružičková et al. 1999).

Koza (2018) evaluated the historical landscape structures with a focus on the agricultural landscape in the cadastral territory of Hriňová. Vašková (2015) analyzed the development of ecosystems in relation to forms of land use in Podpoľanie. Lapinová (2004) dealt with the development of dispersed settlements in the Detva dispersed area region, and together with Paučová (2014), they conducted research in the neighboring district of Detva. Paučová (2014) focused on preserved areas in Detva, specifically on the local part of Skliarovo. Private land ownership, however, was not encouraged after the establishment of socialism in 1948. The established regulations clearly delineated the limits of land that could have been used for farming by private farmers, and the remaining land

was predisposed to collectivization. In the middle of the 20th century, through the process of collectivization, land was collectively pooled. And so, peasant families were left with only small areas up to 0.5 ha (Spišiak 2005).

The shift after 1989 resulted in the conversion of the central planned economy to a market-oriented economy. Despite the fact that farmers in the area once farmed as owners of the agricultural soil, many young people moved for employment to other nearby cities. The growth of Hriňová's population began to decline in 1998 (KPSS 2018). Since then, the city of Hriňová's demographics have taken a negative turn as fewer children are being born, the population is ageing, or the population is post-productive. Nowadays, the area of Podpoľanie is sparsely inhabited, including three settlements, one recreation center, several farms and forest houses (https://en.unesco.org/biosphere/eu-na/polana). Only a few of the 400 permanent residents work in forestry or agriculture, and the majority of them are retired. Those who are working commute to industrial facilities outside the area.

Objectives of the study

Our study provides a detailed description of the historical landscape structures development in the Hriňová – Snohy location. With the years 1949, 2002–2003 and 2018 under examination, the early period of socialism, entry to the European Union and current land use are represented. Landscape dynamics were evaluated on the basis of aerial imagery GIS-based expert classification, in accordance with the CORINE Land Cover methodology modification by Oťaheľ et al. (2017).

We introduced our approach to detailed research of land cover changes of dispersed settlement area in relation to soil and geomorphological conditions. In this paper, we also aim to emphasize any threats that could potentially endanger the future existence of dispersed settlements in Slovakia.

Materials and methods

Study area

The city of Hriňová is located in the Detva district in central Slovakia. Snohy is a local part of Hriňová, situated approximately 10 km north of the city center on the southern slopes at an elevation range 751–828 m a.s.l. The area under investigation is located in Snohy, with a size of 2.5 km^2. It belongs to a moderately cold, very humid district of a cold climate area with an average air temperature in July of 12 °C – 16 °C. The average air temperature in January is from -5 to -6 °C (https://app.sazp.sk/atlassr/).

This is a specific type of dispersed settlement (named „lazy"), where traditional farming has been preserved until today. Hriňová was one of the few municipalities where the collectivization of agriculture never took place, and the Unified agricultural cooperative was thus never established. To this day, it has preserved the traditional structure of land use, which is characterized by terraced fields (Fig. 1). While in the surrounding municipalities of Detva and Očová only a few fragments of agrarian historical structures have remained, compact historical farms have been conserved in the Hriňová dispersed area, being among the best preserved in Slovakia (Urban 2015). Historical landscape

Figure 1. Landscape structure of Hriňová with dispersed settlements and terraced fields (Photo: K. Švoňavová, 2019).

structures are represented by terraced fields and several farms. The study area is a part of the proposed Special Area of Conservation SKUEV4026 Meadows of Poľana with agricultural management (Figs 2, 3). Landscapes of the Poľana Mts. have been protected as the Poľana has been designated as a protected landscape area since 1981, as well as within the Poľana Biosphere Reserve from the UNESCO Man and Biosphere programme since 1990.

The volcanic relief of the Poľana mountain range was remodeled in the Quaternary, mainly by fluvial activity. The soil cover consists mainly of cambisols, andosols, and fluvisols. The territory is located at the upper borderline of a moderately warm climate zone. The region is covered mainly by woodlands (85% of the BR), the rest being agricultural land, including grassland and pastures, except for 50 ha of water reservoir. The forest habitats are diverse, from oak and beech forests to spruce forests growing on andesites, and are well-known for their southernmost occurrence within the Western Carpathians, covering the highest part of the mountain range. Many forests have the character of an old primeval forest. Throughout their history, the Poľana forests have been modified by various natural disturbances and human interventions (e.g., beech forests were replaced by spruce monocultures).

Data

For the purposes of our research, imagery from an aerial survey was used. For the year 1949, panchromatic aerial photographs from the archive of the Topographic Institute in Banská Bystrica with a resolution of 0.5 m (http://mapy.tuzvo.sk) were used. An orthophotomosaic of the Slovak Republic, provided by Geodis ltd. and Eurosense ltd. with a resolution of 0.5 m, was applied for 2003. As for 2018, the open-source Orthophotomosaic of the Slovak Republic was used, carried out by the National Forest Center and Cadastre Authority of the Slovak Republic (https://www.geoportal.sk/en/zbgis/orthophotomosaic).

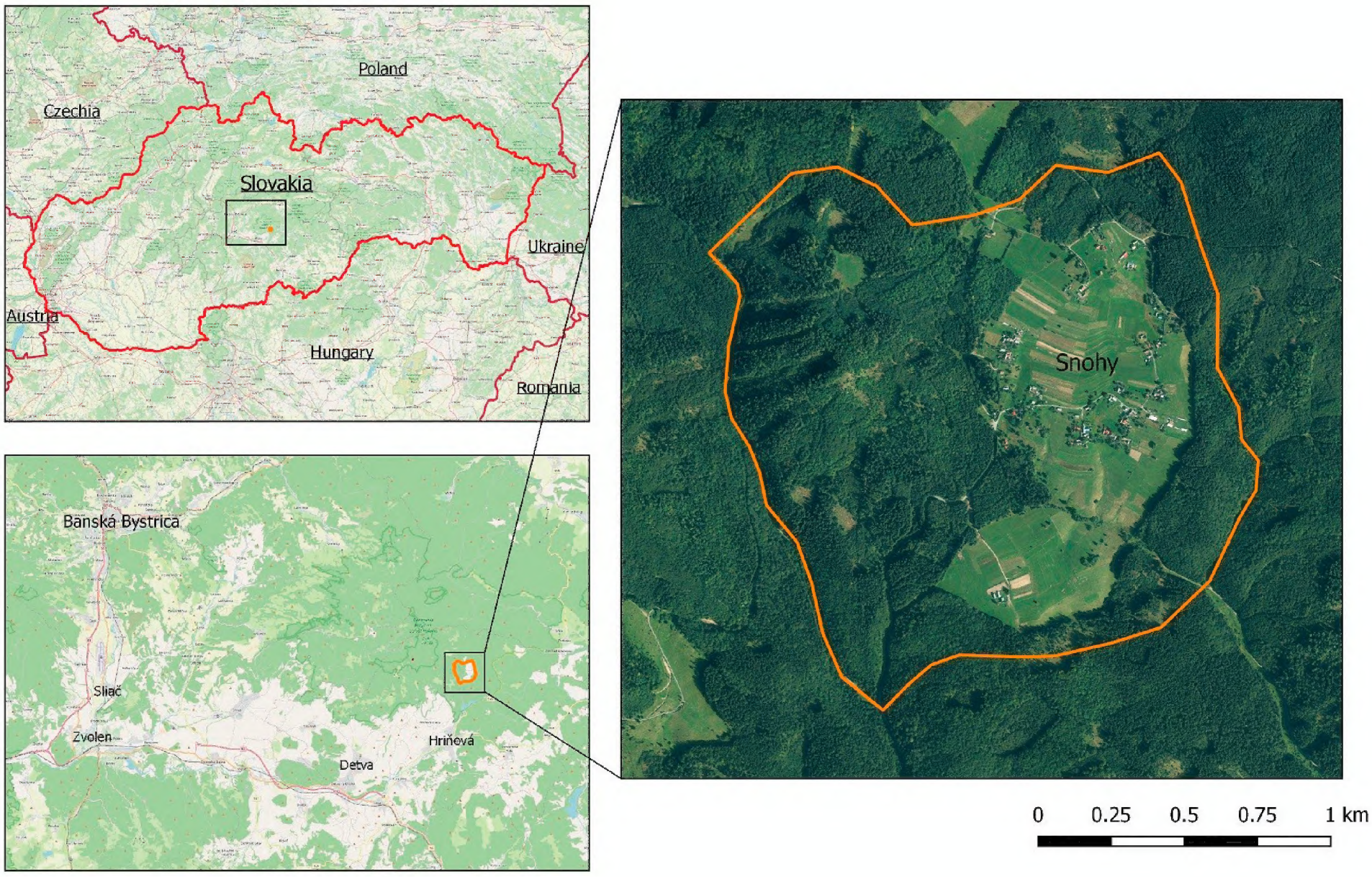

Figure 2. Location of the study area.

Figure 3. Landscape of the study area (Photo: K. Švoňavová, 2019).

Data for the soil maps creation (the map of certified soil-ecological units and forest soil maps) was provided by the Research Institute of Soil Science and Landscape Protection (http://www.podnemapy.sk/portal/verejnost/bpej/) and the National Forest Center (http://gis.nlcsk.org/ArcGIS/services/Inspire/PodneTypy/MapServer/WMSServer?).

The basemap of the Slovak Republic on a scale of 1:10,000 (https://zbgisws.skgeodesy.sk/ZMSR_wms/service.svc/get) and the digital elevation model (DEM) with a resolution of 25 m (https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=mapview) were used to create topographic and insolation outputs.

During the whole analysis, the coordinate system of the unified trigonometric network of the cadastral S-JTSK (5514) was used.

Analysis of land cover changes

The vectorization, as well as the following spatial analysis, were performed in QGIS 2.8.14. The creation of land cover layers was based on visual interpretation. Moreover, data for 2018 was verified by the field research. For identification of land cover classes, the modification of the CORINE Land Cover nomenclature on the 5th level at a scale of 1:10,000 by Oťaheľ et al. (2017) was used.

The method is based on the concepts of hierarchically higher classes (Heymann et al. 1994; Bossard et al. 2000). Most importantly, morpho-structural and physiognomic attributes distinguishing individual landscape objects were respected. The size of the least-identified and simultaneously-recorded area is identical with the study by Druga et al. (2015), who established it at 0.1 ha. It corresponds approximately to a square with a 31.5 m side, a circle with a 35.5 m diameter, or a 20 × 50 m rectangle (Falťan et al. 2020). The minimum area of change is set to 0.02 ha and the minimum width of a polygon to 10 m. Exclusion is made for polygons of linear elements – water courses, railways and road networks – which has a minimal width of 2 m and a minimal length of 50 m.

When mapping land cover for the years 1949 and 2003, the retrospective approach was applied (Feranec et al. 2004), meaning only areas with an interpreted change (larger than the size of the minimum area of the change) were edited. As a reference layer, the layer from the following analyzed year was used. The Change Detection Toolbox tool, which was created as a practical output in Lukáš Žubrietovský's diploma thesis (Žubrietovský 2016), was used in the analysis of the land cover. Classification of changes was carried out according to Feranec et al. (2010).

Temporal stability of each land cover class reflects the degree of its connection to the selected landscape natural components (Súľovský 2017).

The stability of the types of areas used for the land, or of the land cover, also shows the degree of their connection to the selected relevant natural components of the landscape (Súľovský 2017). Land cover stability maps were carried out in the ArcGIS 10.7.1, with land cover change data (1949–2003 and 2003–2018) being the input layers. These layers were overlaid using Intersect tool, and thus we selected unstable areas.

The Merge tool was applied when delineating neutral areas, by merging both layers of the land cover changes. Stable areas are defined as the territory outside any unstable and neutral areas, i.e., an area where no change was recorded.

Analysis of soil and georelief

Based on the underlying soil data, a map was created on a scale of 1:10,000 and the soils were classified according to the soil type and subtype. To unify

soil names, a conversion table, which is freely available on the ForestPortal website about the forests of Slovakia, was used (http://www.forestportal.sk/lesne-hospodarstvo/hospodarska-uprava-lesov/Stranky/prevody-pody.aspx).

A map of morphographic-positional types of georelief according to Tremboš (Minár et al. 2001) was prepared on the basis of the Basic Map of the Slovak Republic in a scale of 1: 10,000 and DEM. When delineating the debatable areas, we used an extracted layer of slope, orientation to the cardinal points, and a layer of contours computed in ArcGIS 10.7.1. Auxiliary contours were created at intervals of 10 m and 5 m. To evaluate the relationship between relief forms and areas of stability, the aforementioned layers were overlaid, and their relationship was examined.

The slope of the soil is an important physical parameter that significantly affects the quality and method of use of the soil and the given location. Layers of slope and insolation were computed from the DEM. In the case of slope, we reclassified raster into six classes. For practical purposes and the needs of agricultural practice, it is possible to express the representation of the slope of agricultural land in the following classes: 0–1°, 1–3°, 3–7°, 7–12°, 12–17°, 17° – 25°, 25° and others. In the case of slope, we reclassified the data in degrees into these classes. Classes 12–17° and 17–25° were merged, as one of the classes was not represented.

Subsequently, raster was converted to the vector feature, while polygons with an area of less than 100 m^2 were merged with the nearest related area. A similar method was used to create the insolation layer: raster was reclassified into six classes, ranging from the minimum value up to 400,000, 400,000–430,000, 430,000–460,000, 460,000–490,000, 490,000–520,000 and 520,000–550,000 WH/m^2. Consequently, layers of slope and insolation were overlaid with the layer of land cover stability so that the underlying relationships could be analyzed.

Results

Analyses of land cover development

In the territory of the Snohy area (Fig. 4), a significant change of the land cover was observed (Table 1). During the period 1949–2003, 52.9% of the total area changed, while during 2003–2018, a change of 28.3% was recorded. In terms of land cover flows during both periods, the most prominent were other changes (61.1 ha = 23.6%), for example, changes in the species composition of stands in the forests or within settlement classes, followed by deforestation (28.0 ha = 10.8%), caused by forest harvesting, and extensification of agriculture (21.8 ha = 8.4%).

In 1949–2003, the most prominent changes were recorded in the structure and composition of forest communities (Fig. 5). The changes in the period of 2003–2018 were similar, however, the other changes had already reached lower values (25.7 ha = 9.9%), yet still being the highest among the others.

This was followed by changes in deforestation (20.8 ha = 8%) and afforestation (18 ha = 6.9%). Artificial areas, fields and meadows in Snohy have changed in all the observed periods (Fig. 6). Significant changes took place in forests under conservation of the Poľana protected landscape area and the

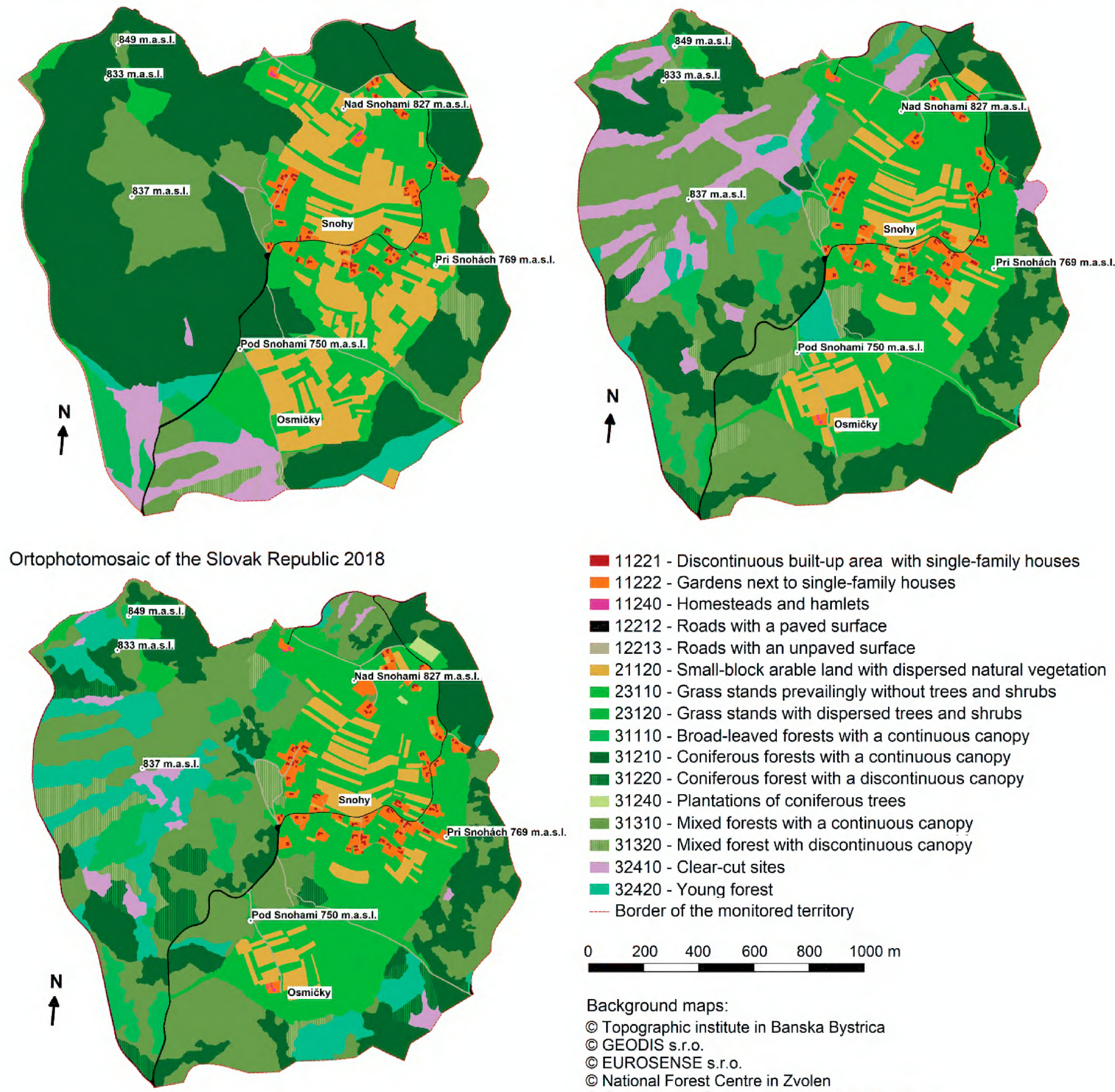
Historical ortophotomap of the Slovak Republic 1949
Digital ortophotomap of the Slovak Republic 2002 - 2003
Ortophotomosaic of the Slovak Republic 2018
849 m.a.s.l.
833 m.a.s.l.
Nad Snohami 827 m.a.s.l.
837 m.a.s.l.
Snohy
Pri Snohách 769 m.a.s.l.
Pod Snohami 750 m.a.s.l.
Osmičky
N
11221 - Discontinuous built-up area with single-family houses
11222 - Gardens next to single-family houses
11240 - Homesteads and hamlets
12212 - Roads with a paved surface
12213 - Roads with an unpaved surface
21120 - Small-block arable land with dispersed natural vegetation
23110 - Grass stands prevailingly without trees and shrubs
23120 - Grass stands with dispersed trees and shrubs
31110 - Broad-leaved forests with a continuous canopy
31210 - Coniferous forests with a continuous canopy
31220 - Coniferous forest with a discontinuous canopy
31240 - Plantations of coniferous trees
31310 - Mixed forests with a continuous canopy
31320 - Mixed forest with discontinuous canopy
32410 - Clear-cut sites
32420 - Young forest
Border of the monitored territory
0 200 400 600 800 1000 m
Background maps:
© Topographic institute in Banska Bystrica
© GEODIS s.r.o.
© EUROSENSE s.r.o.
© National Forest Centre in Zvolen
© Geodetic and Cartographic Institute in Bratislava

Figure 4. Land cover of the Snohy area in 1949, 2003 and 2018.

UNESCO Biosphere Reserve. It must be noted, however, that both active forest management and sustainable agriculture are not prohibited, and are thus encouraged in this zone.

The most stable land cover types are grasslands, followed by coniferous and deciduous forests with a continuous canopy.

Analysis of the influence of slope angle and insolation on the stability of the land cover areas

Unstable areas are connected predominantly to the slope angles 12–25° (19.1 ha) and 7–12° (17.0 ha), being associated with the increased values of deforestation in 1949–2003 (Fig. 8). Areas with a single recorded change are

Table 1. Land cover classes and its area (ha) in each observed time horizon.

Code	land cover type	1949	2003	2018
11221	Discontinuous built-up area with single-family houses	0.90	1.06	1.04
11222	Gardens next to single-family houses	3.78	5.75	6.59
11240	Homesteads and hamlets	0.08	0.05	0.06
12212	Roads with a paved surface	1.37	2.20	2.20
12213	Roads with an unpaved surface	1.99	1.18	0.91
21120	Small-block arable land with dispersed natural vegetation	31.86	15.84	12.05
23110	Grass stands prevailingly without trees and shrubs	46.78	64.69	65.30
23120	Grass stands with trees and shrubs	0.11	3.38	4.14
31110	Broad-leaved forests with a continuous canopy	6.74	8.02	11.51
31210	Coniferous forests with a continuous canopy	116.62	55.85	42.06
31220	Coniferous forests with a discontinuous canopy	0.23	1.51	8.43
31240	Plantations of coniferous trees	0.00	0.00	0.58
31310	Mixed forests with a continuous canopy	29.11	67.92	65.51
31320	Mixed forests with a discontinuous canopy	3.97	5.96	8.29
32410	Clear-cut sites	9.86	18.51	4.73
32420	Young forests	5.36	6.85	25.37

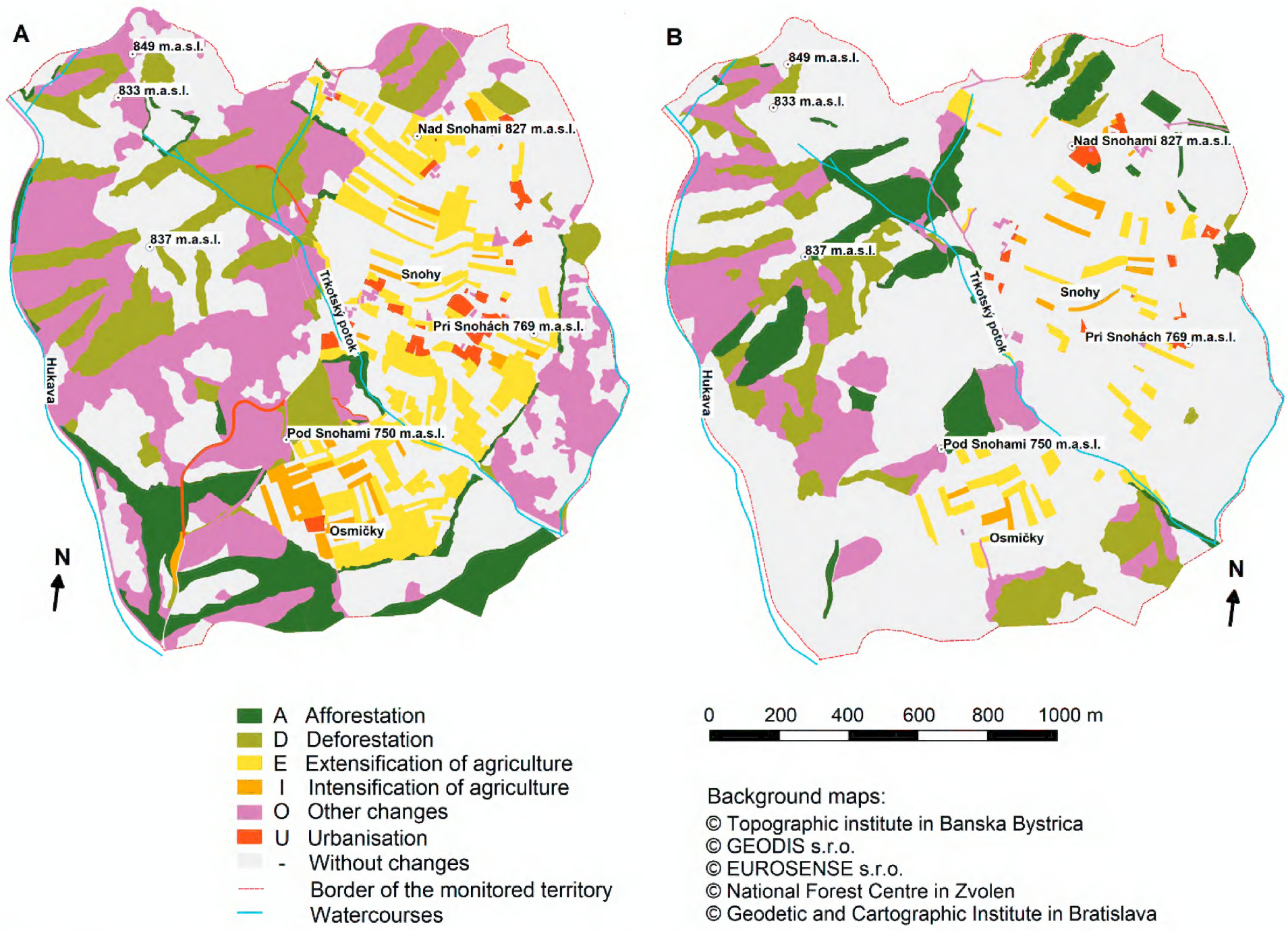

Figure 5. Land cover changes in the Snohy area in 1949-2003 (**A**) and 2003-2018 (**B**).

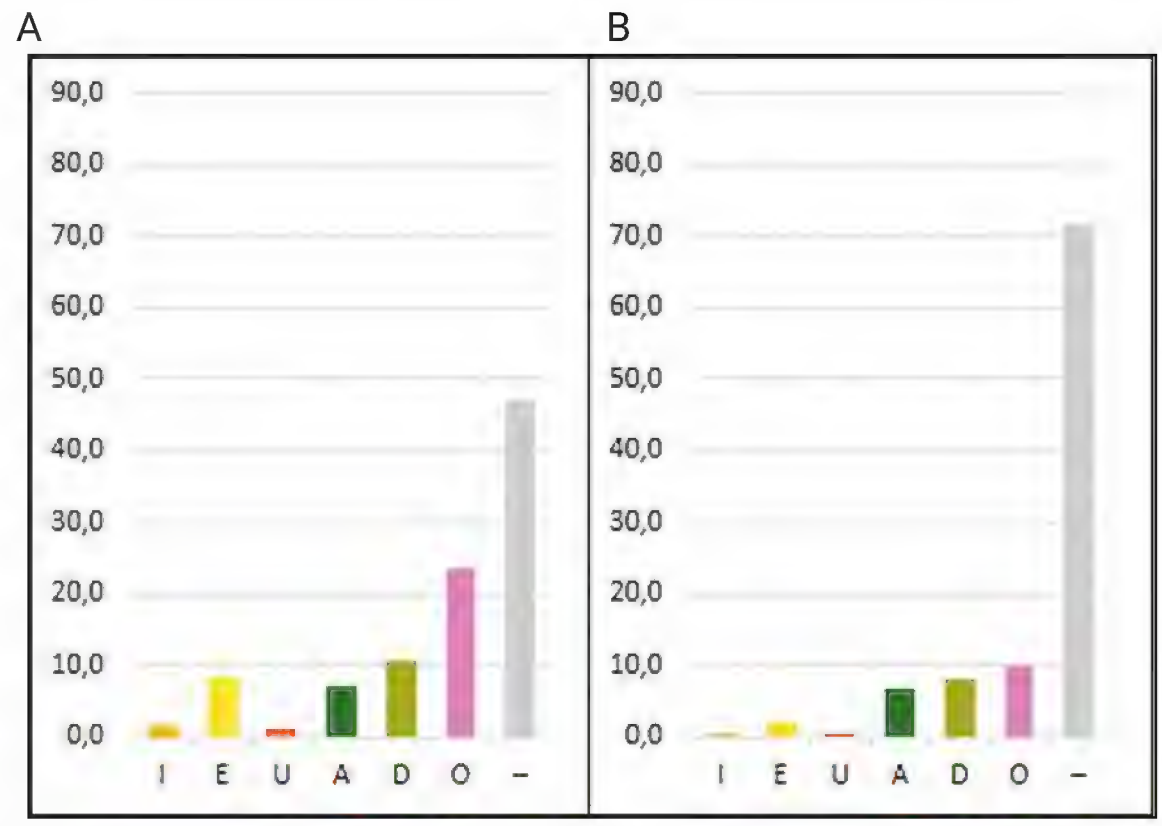

Figure 6. Proportions of individual types of land cover changes (%) in 1949–2003 (**A**) and 2003–2018 (**B**). Type of changes: I – intensification of agriculture, E- extensification of agriculture, U – urbanization, A- afforestation, D - deforestation, O – other change, - - without change.

linked to afforestation, significant extensification after 1950, and subsequent intensive deforestation between 2003–2018 (Fig. 8). Areas with steep slopes were marginally modified during 1949–2018, being covered mostly by forests.

The most significant category of the total insolation in the entire territory was 460,000–490,000 Wh/m^2 (104.5 ha = 40.4%). Moreover, the amount of insolation ranging from 490,000 to 520,000 WH/m^2 took place in the area of 69.3 ha (26.8%). The category of 520,000–536,300 Wh/m^2 was spatially detected in the area of 3.5 ha, being the highest value of insolation among dispersed settlements throughout the entire Hriňová region.

Unstable areas with higher insolation values showed the most significant processes of afforestation, deforestation, and other changes in the entire observed period of 1949–2018 (Fig. 7). Neutral areas in the sunniest parts of the territory were characterized by changes in deforestation, other changes until 2003, and increased extensification and other changes after 2003. The land cover in the areas with a higher insolation values was represented by forest communities, arable land, and grasslands.

The influence of georelief forms and soil types on the stability of land cover areas

In the study area, the predominant soil type is locally-andotermic cambisol (Fig. 7). In the floodplains, fluvisols take place, being characteristic for the areas modified by a single change type (mostly deforestation). In the areas with prevailing cambisols, the land cover types stability was influenced mainly by the forms of georelief. The most significant changes were linked to deforestation in the second half of the 20th century, as well as afforestation and extensification at the beginning of the 21st century. These changes took place on 46% of the transport slopes.

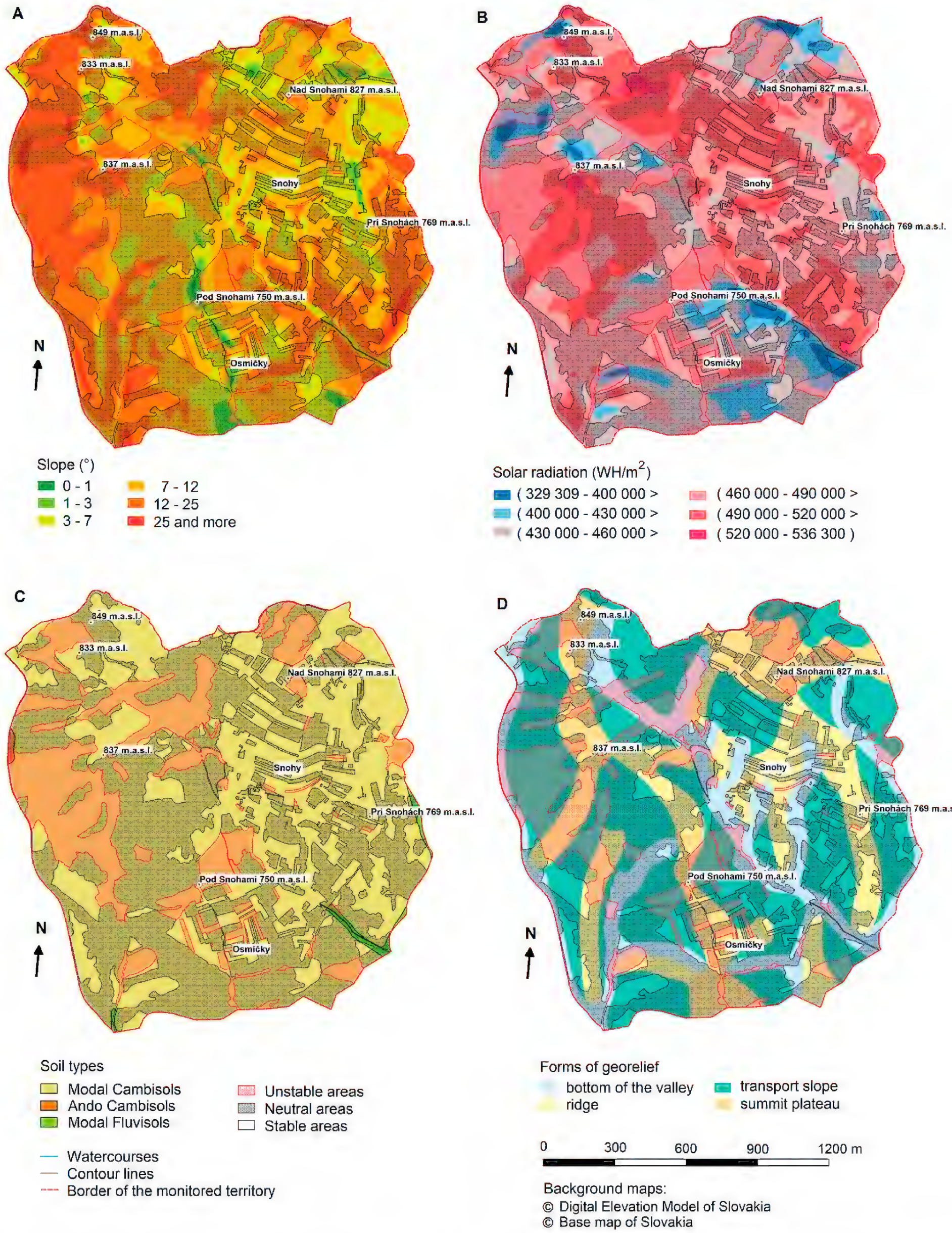

Figure 7. Stability of land cover areas in relation to the **A** slope angle **B** insolation **C** soil types **D** form of georelief.

Almost 20% of the valley bottoms and ridges has been modified by similar processes. However, stable areas are connected mainly to the transport slopes and not to the ridges and valley bottoms.

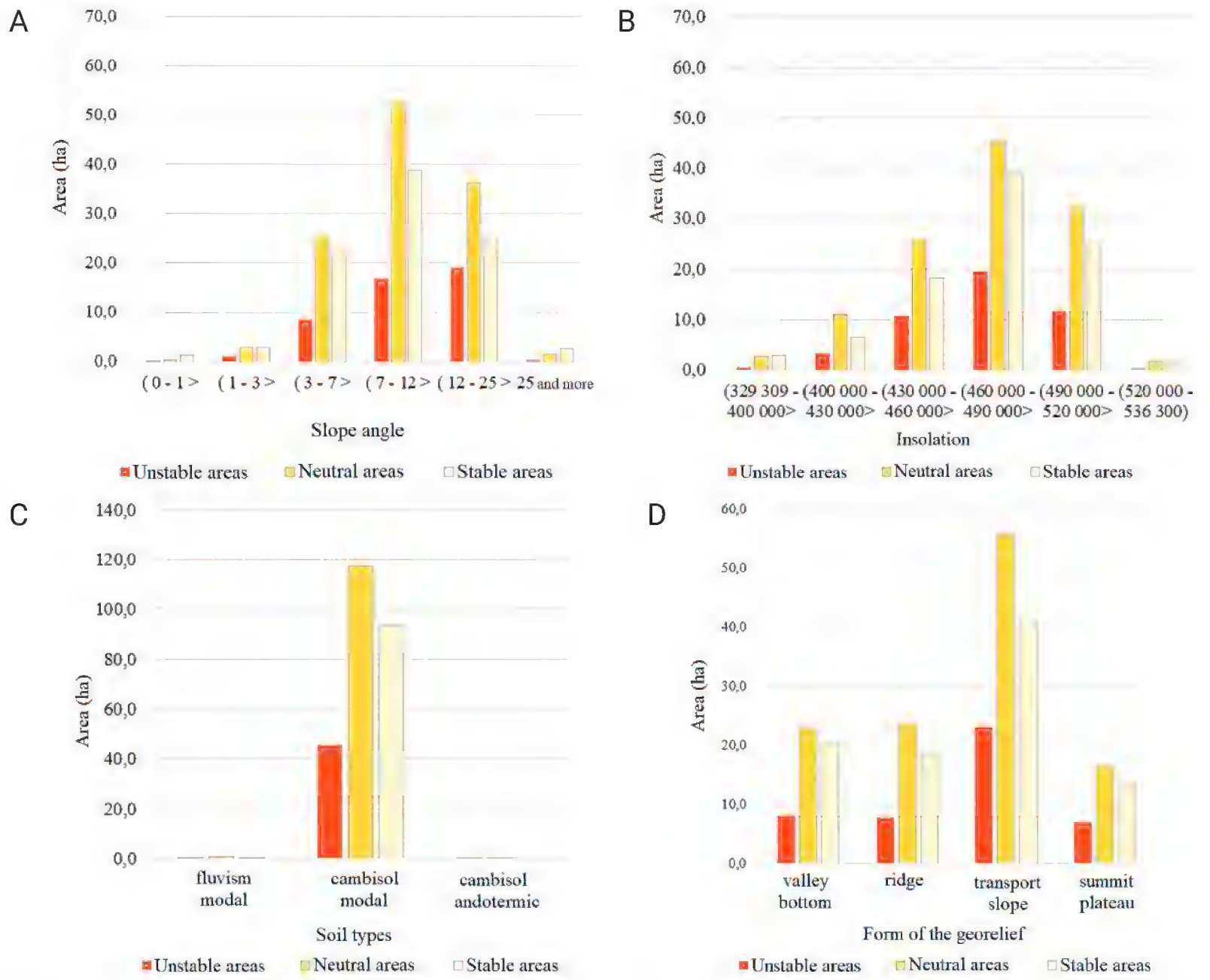

Figure 8. Stability of land cover areas in relation to the **A** slope angle **B** insolation **C** soil types **D** form of georelief.

Discussion

Long-term changes in land use also affect other environmental determinants, such as elevation, slope, insolation, or wetness of the soil (Druga and Falťan 2014). The drivers for the agricultural intensification and urbanization seem to be similar for both old democratic and post-socialist countries. In contrast, agricultural land abandonment in the old democratic countries was driven by technological, cultural and economic driving forces while in the post-socialist countries the political driving forces were mainly responsible (Skokanová et al. 2016).

According to several studies (Boltižiar and Olah 2009; Žigrai 2000), changes in the landscape and their spatial determinants are most intensively related to the most significant socio-political periods, namely socialism (1980–1990), post-socialism (1990–2000), accession to the EU (2000–2006), and EU membership (2006–2012). Pazúr et al. (2014) point to significant changes in the landscape management associated with institutional changes, especially in the post-socialist period. It was during this period that the protected landscape area of BR Poľana, established in 1981, was also included in the network of biosphere reserves in 1990, and until 2010, only its protective function was mainly ensured (Urban 2015). This was also reflected in a certain stabilization of the use of the territory and therefore roughly 70% of the territory was categorized as “no change” between 2003 and 2018 (Fig. 5B). The land cover changes in both evaluated periods took place mainly in forestry and agriculture, which, after the inclusion of Poľana in the network of biosphere reserves, are supported as close to nature forest management and sustainable agriculture, which is relevant also in our study area.

The territory that the Poľana biosphere reserve belonged to in 2014 was among the least urbanized protected areas in Slovakia. There were only three settlements (Iviny, Snohy and Vrchslatina) with a typical settlement (about 400 permanent residents in total) (Urban 2015). In 2016, Hriňovské lazy was also included in the transition zone. Scattered settlements were created in Hriňová due to the difficult availability of land from inhabited areas. In this area, horses and traditional agricultural tools are still used for agricultural work. This agro-ecosystem not only fulfils the function of a producer of food, feed and raw materials, but also supports a whole range of non-production functions of the country and thus becomes more sustainable (Prčík et al. 2019). The cadastral territory of Hriňová, as one of the few in Slovakia, was not affected by the collectivization of agriculture during the socialist period; it has preserved its unique landscape and traditional forms of farming. The preservation of these traditional forms of agriculture is mainly ensured by the work of the Coordinating Council of the Poľana Biosphere Reserve with stakeholders. In 2017, the Poľana Biosphere Reserve received the Michel Batisse Award for the Biosphere Reserve Management at the ceremonial event in the course of the ICC MAB, the highest possible award for the exceptional experience of man with nature.

Hanušin et al. (2020) claim that dispersed settlement with a residential or landscape area structure, significant building, and social and cultural peculiarities, create unique manifestations of material and spiritual heritage and genius loci. According to Woods (2005), a country with scattered population represents in most regions of Europe a specific type of rural landscape that has seen a significant change in recent times, predominantly during the twentieth and the beginning of the twenty-first century. Social and technological modernization has affected almost all areas of rural life. In Slovakia, regions with a dispersed settlement on mountain slopes have been changing their appearance and function for approximately the last 30–50 years. According to previous studies (Bezák and Halada 2010; Bezák and Mitchley 2014; Bezák and Petrovič 2006; Bezák et. al 2020), the main factors of changes were related to the onset of socialism after World War II, political and economic changes after 1989, and Slovakia's accession to the EU. Socialism led to the establishment of State Property (SP) and United Agricultural Cooperative (UAC); narrow-band fields were consolidated into larger blocks. Increase in production and decrease in agricultural landscape diversity were significant. UAC was a type of agricultural cooperative in the Czechoslovak Socialist Republic until 1990. UACs were responsible for most of Czechoslovakia's agricultural production. Any citizen could become a member after completing compulsory schooling. Upon joining the cooperative, a member of the cooperative handed over all the agricultural land he owned to the ownership and joint management of the cooperative. SPs were fully owned by the socialist state and they managed a smaller area of land than UACs in Slovakia.

After 1989 the population began to lose interest in agriculture, mostly in regions with dispersed settlements. The consequences for the landscape were thus significant: a large part of the agricultural land was abandoned, grassed-over, and overgrown with scrub. In Hriňová, due to the character of the landscape, there was no consolidation of offields during socialism. At the same time, the area of small-block, arable land with dispersed natural vegetation and coniferous forests with a continuous canopy managed by foresters gradually

decreased in the Snohy study area from the middle of the 20th century. The area of gardens next to single-family houses, grass stands, and natural mixed forests has increased.

In the highly-fragmented agricultural patterns, which are typical of a traditional agricultural landscape, significant changes are not observable by conventional remote sensing approaches to land change measurement (Ellis et al. 2006). Specific research procedures included large-scale mapping based on aggregation data, such as historical records, field mapping combined with multiple level approaches that define land system – land cover – land use, cultural heritage features, and vegetation (Ellis et al. 2009; Kizos et al. 2010). Several detailed field investigations were carried out in the locality. The territory of the Hriňová dispersed settlement landscape became an object of interest for Mojses and Petrovič (2012, 2013). In addition to the changes in the land cover, they focused on other specific types of historical structures of the agricultural landscape, while the extensification of agriculture was recorded as the second most widespread type of change in the period from 1949 to 2010. The land cover changes recorded in this region were the result of several negative socioeconomic influences, such as unsuitable economic conditions, legislative and administrative obstacles, or the aforementioned loss of ties to the traditional way of farming. Krnáčová and Hreško (2014) came up with the suggested management and measures, which were based on the observed soil reaction of the management of agricultural biotopes, and described in detail the functions of vegetation and vegetational-anthropogenic elements of the agricultural landscape. With regard to the prepared site of NATURA 2000, it is necessary to preserve the agricultural management of meadows, gardens, and block fields in the Snohy area.

The development of mining and metallurgy in the 19th and 20th centuries caused significant logging and transformation of deciduous and mixed lowland forests into spruce monocultures (Urban 2015). The extracted wood was used in glassworks, in the production of charcoal or intended for export. More studies (Izakovičová 2013; Bezák and Mitchley 2014) link landscape changes with migration in Europe after World War II. The population tends to concentrate in bigger cities as a result of higher population density. This brings more opportunities for jobs, entertainment, and the social aspects of life (Antrop 2004). In the nearby surroundings of our study area, Detva and Hriňová, cities that attract the majority of the population, such as Zvolen, Banská Bystrica, or Brezno, can be found, which also provide better job prospects and improved cultural benefits while still being within reasonable distance of Poľana. A low population density without local services restricts viable employment opportunities (Lundmark et al. 2010). Generally speaking, the depopulation of dispersed settlements might have a serious effect on sustainable development of the region (Grau and Aide 2007). Although dispersed settlement has an irreplaceable ecological, cultural, and historical value, the interest of local owners in traditional farming is constantly decreasing in Slovakia (Pazúr et al. 2020). Olah et al. (2006) point out the impact of the decreasing number of farming inhabitants around Podpoľanie and the related reduction of the area of the managed permanent grasslands. Young people from Snohy also often left to work in nearby towns. The ecologically most stable areas lie in the lowest, southern, and south-western slopes in the region of the Poľana Biosphere Reserve (Olah 2003, 2006). Gallayová (2009) showed that overgrowths above 75% are clearly linked to the

slopes higher than 15° in the territory of Poľana, which was also confirmed in previous research. It was similar in the analysis of soil types, where modal cambisol reached increased values in areas with a higher intensity of change or overgrowth. Galalyová registers overgrowth of over 75% in the areas oriented to the northwest, north and west. The smallest overgrowth was identified on the southern and eastern slopes. According to Žigrai (2000), distance plays an important role in the assessment of the relevant socioeconomic element.

Huba (2009) focused on the transformation of the dispersed settlement area on the example of Poľana. One type of secondary resettled population is the descendants of the original owners who decided to settle in this region and start farming. Another type are people who are looking for a second home or cottage, while at the same time carrying out agricultural and economic activities around the property. Nowadays, we can register a third type of residents, i.e., the descendants of the original owners, who live in either the original or newly-built houses, but are not interested in agricultural activities. This phenomenon is described also by Štefunková (2019). Therefore, land use changes are gradually taking place — overgrowth, conversion to recreational land, etc. This process is also evident by a slight increase of a discontinuous, built-up area with single-family houses in Snohy in recent years. Several authors have also reported changes in agricultural activities, which could create risks to the preservation of the traditional cultural landscape (Agnoletti 2007; Špulerová 2008; Van de Velde et al. 2010; Jakab and Petluš 2012). Another factor that potentially endangers the continuity of such areas is depopulation (Elbakidze and Angeltram 2007). Therefore, it is of utmost importance to find solutions to these problems, because research results confirm the irreplaceable role of HSAL (Deckers et al. 2005).

In the study of land cover changes around the villages of Malachov and Podkonice in Central Slovakia west of the Podpoľanie region, Druga and Falťan (2014) also confirmed a reduction of arable land during last century. Elevation and higher slope angle were related to the classes with lower intensity of use, such as forest land and extensive grassland, which is in our study too. Steep areas with a slope of more than 12°, despite having a higher amount of insolation, have been predominantly used for forestry after 1949. The trends of extensification of agriculture and afforestation have manifested more than urbanization in dispersed settlement localities. Löw and Míchal (2003) recorded fields from one settlement as having a maximum diameter of 1.2 km. In several studies (Hietel et al. 2004; Bárek et al. 2009; Martínez 2011; Tárnik and Igaz 2015), it has been stated that soils have minor or average influence on land cover changes. In our study, stability of land cover has been influenced more by georelief.

An interest in maintaining the integrity of traditional landscapes is also present in the European Landscape Convention (CETS No. 176 2000), because there are real threats of losing traditional landscapes and their genius loci. The recent CAP approach does not sufficiently reflect the specific local physical conditions of Slovak TALs. For example, small, remote meadows, and narrow fields with terraces and stone walls, typical for Podpoľanie area, are not included in the support system (insufficient size, difficult access). The system is financially demanding and inaccessible for many rural farmers. Administrative tasks are a huge barrier, especially for older people. This challenge of maintaining traditional agricultural landscapes is addressed to individuals, as well as to those politicians who make decisions on development policy (MRI).

Due to its location, Snohy and its wider surroundings have long been part of the Protected Landscape of Poľana, specifically falling into the transition zone. Logging is not prohibited in this zone, but practices of sustainable management of natural resources are promoted and developed in it. Compared to the unprotected forest land in the vicinity, the share of deciduous forests is gradually being restored here. The territory of Snohy is included in the upcoming part of the NATURA 2000 network, Special Area of Conservation SKUEV4026 Meadows of Poľana, which is supposed to protect valuable meadow biotopes: species-rich Nardus grasslands, on siliceous substrates in mountain areas and submountain areas in continental Europe, lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*), transition mires and quaking bogs and a species of European importance, *Campanula serrata* (https://www.minzp.sk/uradna-tabula/eu-uzemia/skuev4026-luky-polany.html). In 2021, negotiations began with the owners, managers, and tenants of the affected lands. According to Article 6(3) of the Habitats Directive 92/43/EEC1 (HD), any projects and plans within these sites or in their vicinity require an appropriate assessment to ensure that they will not have any significant impact on the integrity of the Natura 2000 site (Mockel 2017). This process is complicated in the territory of Podpoľania by the number of owners and users of the agricultural landscape. This region is very interesting from the point of view of landscape preservation, as well as for the monitoring and research of other connections.

Some studies have shown that the impact of settlement on landscape fragmentation in biosphere reserves has been more significant (Compas 2007; Liang et al. 2014; Li et al. 2023), and the interactions between settlement landscape patterns and natural ecosystems have been more complex (De Castro-Pardo et al. 2021). The area, number, density, connectivity, shape similarity, and spatial organization of patterns of settlements have had a significant impact on the size of biological communities and the species richness in biological reserves (Heider et al. 2018; Lu et al. 2018; Onilude and Vaz 2020; Wang et al. 2020). Woodland landscapes in mountainous areas have been characterized by high biodiversity and contain rich populations of plant and animal species (Bailey et al. 2002), so the influence of woodland landscape fragmentation is more complex, as compared to other types of landscapes (Pavlacky and Anderson 2007).

Our proposed methodology can be used in other Central European countries. Data for the soil maps creation is available in the portals of the forestry and agriculture research institutes. Digital elevation models, as a data for GIS georelief analyses, can be obtained according to the possibilities of state geodetic and cartographic authorities in different countries. Land cover mapping is realisable with the use of actual open remote sensing data and historical orthophotographs with interpretation procedures and nomenclature designed in the work Oťahel' et al. (2017). The use of the CLC at the 5th level is methodologically possible throughout the European Union. The legend is usable in Central Europe, but of course, it can be expanded by adding specific types of areas (e.g. coast, forest-steppe, tundra, etc.). However, it should be noted that the process itself is more time-consuming compared to the use of satellite images for the CLC program and it is not very suitable for larger regions. The output of our work will be further used in the landscape management of the PLA Poľana, as the staff of the PLA administration requested them.

We perceive that globalization leads to the creation of a uniform society, as well as to the loss of the specificity of regions to varying degrees. This is gradually reflected in the formation of the landscape and scattered settlements. The landscape is changing into homogeneous units — peripheral settlements that had an agricultural and manufacturing function in the past are disappearing. Forms of anthropogenic relief in a traditional agrarian landscape are an important part of cultural heritage and, at the same time, a source of biodiversity. They were created over many centuries to improve the quality of the relief soil of agricultural land and contain specific features as a result of the local agrarian culture and specific natural conditions. The benefit of the research is a detailed evaluation of the development of the land cover of the territory with scattered settlements in the location of Snohy, which points to significant changes in the use and transformation of the landscape.

Conclusions

The area of Podpoľanie with the „lazy“ dispersed settlement under the Poľana Biosphere Reserve, thanks to a specific method of management, has preserved several valuable historical landscape structures (e.g. terraced fields and fragments of non-forest woody vegetation). Our study introduced a new approach to deatiled research of land cover changes of dispersed settlement area in relation to soil and geomophological conditions. Since 1949, there has been a significant change in the land cover in more than half of the Snohy territory, mainly in the structure and composition of the forest communities. The relief factors were significantly dominated by the influence of the slope on land cover changes. Stable areas of forests were linked to slopes higher than 25°, transport slopes with a slope angle of 12–25° represented habitats with deforestation in the 20th century and afforestation in the 21st century. At the same time, the gradual extensification of agriculture was promoted. Research did not show any effects that would clearly indicate changes related to areas with very low insolation intensity. We can confirm the biggest changes occurred in the modal cambisol, and that the land cover areas linked to the fluvisol and andosol was more stable, regarding the soil types.

The city of Hriňová, in cooperation with the Poľana Biosphere Reserve, has implemented several arrangements to prevent the loss of diversity in this region. In 2016 the inclusion of the Hriňová dispersed settlements in the Biosphere Reserve marked another step forward in the sustainable development of the region. In 2016, Hriňovské lazy was also included in the reserve transition zone, where horses and traditional agricultural tools are still used for agricultural work. The main goal is to direct investments into the creation of new job offers, as well as into the creation of regional products and projects that will help preserve the customs and landscape character of the Podpoľanie region. The establishment of Special areas of Conservation (SACs) Meadows of Poľana, including locality Snohy, can significantly help preserve biodiversity in this area.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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